Competitive Tax Reforms in a Monetary Union with Endogenous Entry and Tradability

Stéphane Auray, Aurélien Eyquem, Xiaofei Ma

GATE LYON SAINT-ÉTIENNE
UMR 5824

93, chemin des Mouilles
69130 Ecully - France

Maison de l'Université, Bâtiment B
10, rue Tréfilerie
42023 Saint-Etienne cedex 02 - France

http://www.gate.cnrs.fr
gate@gate.cnrs.fr

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JEL codes:
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Stéphane Auray† Aurélien Eyquem‡ Xiaofei Ma§

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†CREST-Ensai and ULCO; e-mail: `stephane.auray@ensai.fr`.

‡Univ Lyon, Université Lumière Lyon 2, GATE L-SE UMR 5824, F-69130 Ecully, France; e-mail: `aurelien.eyquem@univ-lyon2.fr`.

§Université d'Evry and Univ Lyon, Université Lumière Lyon 2, GATE L-SE UMR 5824, F-69130 Ecully, France; e-mail: `xiaofei.ma@ensai.fr`.

1 Introduction

Fiscal devaluations have recently attracted a lot of attention among policymakers of the Eurozone. The constraint on nominal exchange rates imposed by monetary unification makes the reduction of external imbalances more difficult, which has become problematic since the 2008 Great Recession and the subsequent Eurozone crisis. Fiscal devaluations are tax reforms that shift the tax burden from a base to another, trying to replicate the path of terms of trade that would be achieved after a nominal exchange rate devaluation. They have appeared as a potential cure. Portugal recently announced that a fiscal devaluation would be implemented. Some countries such as Denmark (in 1987), Germany (in 2007) or France (2012) already proceeded to shifts in the tax burden from labor income to consumption taxation. The expected effects from such policies are a reduction in labor costs, production costs and a change in the relative price of tradable goods, leading to an expenditure switching effect towards domestic goods that improves the trade balance, with positive effects on output and employment. However, because this type of reforms leads to changes in the structure of taxes, it also shapes the extent of distortions in the economy and might result in structural changes, something that nominal exchange rate devaluations do not imply. We therefore choose to refer to these policy options as competitive tax reforms, precisely because we study their impact both on key macroeconomic aggregate variables, the relative price of traded goods and the distortions of the economy.

In this paper, we investigate the effects of competitive tax reforms using a two-country monetary-union model with endogenous varieties and endogenous tradability.[1] The model derives from Auray, Eyquem & Poutineau (2012) and Cacciatore & Ghironi (2014). As usual, endogenous tradability is introduced by an entry condition on export profits, and endogenous entry derives directly from expected profitability conditions.[2] Carefully calibrated to countries of the Euro Area and driven by standard productivity and monetary policy shocks, the model successfully replicates a large set of business cycle moments, including business cycle moments pertaining to the creation of new ventures. We then use the model to account for the effects of a competitive tax reform that temporarily raises VAT and lowers the payroll tax rate in a way that keeps the government budget balanced each period.

The theoretical channels through which competitive tax reforms can affect the economy were recently studied by Farhi, Gopinath & Itskhoki (2014). They show that allocations implied by nominal exchange rate devaluations may be replicated under an extensive set of assumptions regardless of the size of the targeted devaluation, and provided governments have access to a sufficiently large number of tax instruments. Hence, changes in the tax mix can help governments

[1]The paper thus belongs to the open-economy literature with heterogeneous firms and/or endogenous tradability along the lines of Bergin & Glick (2009), Bergin & Lin (2012), Naknoi (2008), or Roriguez-Lopez (2011) among others.

[2]Our entry condition depends on expected profits and is therefore equivalent to the condition proposed by Ghironi & Melitz (2005).

affect the terms of trade and real exchange rates within a monetary union. These changes may generate external rebalancing effects and a rise in GDP through exports and the rise of hours worked as well.[3] In line with the literature, we find that a competitive tax reform boosts output, consumption, and hours worked. The relative price of traded goods falls, leading the trade balance to improve after a few periods. Our results thus comfort existing studies about the overall effects of competitive tax reforms.[4]

However, most papers focusing on the effects of competitive tax reforms or fiscal policy in open economies disregard their potential effects on the patterns of trade and business creation. Their scope is therefore limited to the effects on the intensive margin of trade, *i.e.* expenditure switching and international wealth effects (see Bosca et al. (2013), Lipinska & von Thadden (2012) or Langot & Lemoine (2014)). Since Ghironi & Melitz (2005) however, we know that changes in terms of trade not only induce expenditure-switching or wealth effects, but also impact the number of varieties produced and traded in the economy, with strong effects on the overall degree of trade openness in the economy and on aggregate productivity (even for a given distribution of firm-specific productivity levels) through firms' entry and market share reallocations.[5] Hence, any change in the taxation of goods and labor that affects terms of trade should translate into significant effects on the number of produced and traded varieties.

In this paper, we uncover an important and undocumented transmission channel of competitive tax reforms that relies on business creation. Endogenous business creation and the introduction of new varieties of products has long been identified as an important source of economic fluctuations.[6] We show that allowing for endogenously produced varieties magnifies the response of domestic output, investment, consumption and hours worked to a competitive tax reform compared to a model with a constant number of varieties. In addition, this assumption induces a *positive* transmission to the foreign economy (output in particular) while the transmission is *negative* when the number of produced varieties is held constant.

The mechanism at work is quite simple to grasp. A competitive tax reform leads the foreign real wage to fall and boosts output in the domestic economy. Both features raise the expected profits of foreign firms and boost foreign business creation. This rise in the extensive margin of

[3] Relatedly, Langot, Patureau & Sopraseuth (2014) analyze the optimal taxation scheme in an open economy with search labor market frictions.

[4] A recent study by the European Commission (2013) uses general equilibrium models to quantify the effects of fiscal devaluations and concludes that fiscal devaluations induce an expansion of employment and GDP, while the trade balance reacts positively in the short-run. Bosca, Domenech & Ferri (2013) develop a general equilibrium model of a small open economy with search and matching frictions calibrated to Spain. They show that a fiscal devaluation may be effective in stimulating output, hours worked and the trade balance. Engler, Ganelli, Tervala & Voigts (2014) propose a New-Keynesian model with Ricardian and Non-Ricardian households and sticky wages and find similar results.

[5] See also the recent contribution of Imura (2016).

[6] See Bilbiie, Ghironi & Melitz (2012) and references therein for the importance of business creation in closed economies and Auray & Eyquem (2011) in open economies.

foreign output and consumption more than compensates the fall in the intensive margin, and output rises instead of falling, as when the number of varieties is constant. Last but not least, we show that the lifetime welfare effect of a domestic competitive tax reform are positive for both countries and larger than in alternative models with a constant number of varieties, because the efficiency gains from the reform are larger.

Our results hold when the competitive tax reform is implemented around the steady state or conditional on an asymmetric shock on borrowing and entry costs that mimics the recent slowdown observed in countries of the periphery of the Euro Area. In the latter case, a competitive tax reform also proves to have interesting stabilizing properties with fairly small negative side-effects on other members of the monetary union. Further, we quantify the impact of pre-announcing competitive tax reforms. We find that the announcement pattern crucially alters the way welfare gains and losses materialize over time. Finally, a sensitivity analysis indicates that our results are fairly robust to changes in key parameters.

The paper is organized as follows. Section 2 presents the model used to analyze competitive tax reforms. Section 3 presents the calibration of the model and performs a business cycle moments matching exercise. Section 4 comments on the dynamics implied by competitive tax reforms whether they are done around the steady state or conditional on a negative asymmetric shock on borrowing and entry costs, and provides a robustness analysis. The welfare and efficiency effects are also reported and analyzed. Section 5 concludes.

2 Model

As in Auray et al. (2012), we consider a model of endogenously produced and traded varieties along the lines of Ghironi & Melitz (2005), and incorporate sticky prices in the retail sector as well as fiscal instruments. However, as in Cacciatore & Ghironi (2014), we consider an intermediate sector producing goods that serve as inputs in the production of final goods, and that are used to pay entry and export costs. Fiscal policy instruments are the VAT and payroll tax rates. They alter the conditions of production in the intermediate and final sectors with strong implications on entry in domestic and export markets, and with general equilibrium effects.

2.1 Households

Each country is populated with a representative household. In the home country, the representative household maximizes a welfare index:[7]

$$\mathcal{W}_t = \mathrm{E}_t \left\{ \sum_{s=t}^{\infty} \beta^{s-t} u\left(c_s, \ell_s\right) \right\} \tag{1}$$

[7] We do not describe in details relations characterizing the foreign economy. However, similar conditions hold.

subject to the budget constraint:

$$b_t + p_t\left(c_t + ac_{b,t}\right) = r_{t-1}b_{t-1} + w_t\ell_t + p_t\left(\kappa_t + \upsilon_t\right) - tax_t \tag{2}$$

and to the appropriate transversality conditions. In the above expressions, β is the subjective discount factor, c_t is the aggregate consumption bundle, ℓ_t is the quantity of labor supplied. Domestic households have access to a nominal bond issued in the monetary union in quantity b_t, that pays a risk-free nominal interest rate r_{t-1} between periods $t-1$ and t. Trading bonds requires the payment of adjustment costs $ac_{b,t} = \phi^b\left(b_t/p_t - b/p\right)^2/2$. Further, p_t denotes the CPI in the domestic country in period t, w_t is the real wage rate, κ_t and υ_t are the total real profits received respectively from monopolistic final goods producers and from the retail sector. Variable tax_t is a lump-sum tax. In period t, the household determines the optimal consumption c_t, labor supply ℓ_t, and the amount of bonds b_t. Combining first-order conditions yields:

$$\mathrm{E}_t\left\{\beta_{t,t+1}\frac{r_t}{\pi_{t+1}\left(1+\phi^b\left(b_t/p_t - b/p\right)\right)}\right\} = 1 \tag{3}$$

$$u_{\ell t} + u_{ct}w_t/p_t = 0 \tag{4}$$

where $\beta_{t,t+1} = \beta u_{ct+1}/u_{ct}$ is an adjusted discount factor and where $\pi_t = p_t/p_{t-1}$ is the CPI inflation rate. The first condition is the Euler condition on bonds and the second is the labor supply equation. Aggregate consumption is a bundle of the different local varieties ω of retail goods:

$$c_t = \left(\int_0^1 c_t\left(\omega\right)^{\frac{\eta-1}{\eta}}d\omega\right)^{\frac{\eta}{\eta-1}} \tag{5}$$

and the corresponding CPI is

$$p_t = \left(\int_0^1 p_t\left(\omega\right)^{1-\eta}d\omega\right)^{\frac{1}{1-\eta}} \tag{6}$$

which produces the following demand functions

$$c_t\left(\omega\right) = \left(\frac{p_t\left(\omega\right)}{p_t}\right)^{-\eta}c_t \tag{7}$$

Bond adjustment costs $ac_{b,t}$ and public spending g_t are also expressed in units of this bundle and add-up to total demand.

2.2 Firms

The retail sector aggregates n_t domestic varieties and $n^*_{x,t}$ foreign varieties according to

$$y_t\left(\omega\right) = \left(\int_0^{n_t} y_{d,t}\left(z,\omega\right)^{\frac{\theta-1}{\theta}}dz + \int_0^{n^*_{x,t}} y^*_{x,t}\left(z,\omega\right)^{\frac{\theta-1}{\theta}}dz\right)^{\frac{\theta}{\theta-1}} \tag{8}$$

where $\theta > 1$ is the elasticity of substitution between different varieties.[8] The nominal marginal cost attached to this bundle is:

$$mc_t(\omega) = mc_t = \left(\int_0^{n_t} p_{d,t}(z)^{1-\theta} dz + \int_0^{n^*_{x,t}} p^*_{x,t}(z)^{1-\theta} dz \right)^{\frac{1}{1-\theta}} \tag{9}$$

where $p_{d,t}(z)$ is the price of domestic varieties and $p^*_{x,t}(z)$ is the domestic price of imported varieties. Optimal good demands respectively from domestic and foreign retailers are

$$y_{d,t}(z,\omega) = \left(\frac{p_{d,t}(z)}{mc_t} \right)^{-\theta} y_t(\omega) \text{ and } y^*_{x,t}(z,\omega) = \left(\frac{p^*_{x,t}(z)}{mc_t} \right)^{-\theta} y_t(\omega) \tag{10}$$

$$y^*_{d,t}(z,\omega) = \left(\frac{p^*_{d,t}(z)}{mc^*_t} \right)^{-\theta} y^*_t(\omega) \text{ and } y_{x,t}(z,\omega) = \left(\frac{p_{x,t}(z)}{mc^*_t} \right)^{-\theta} y^*_t(\omega) \tag{11}$$

Each variety of retail good ω is sold at price $p_t(\omega)$ subject to Rotemberg adjustment costs. Optimal pricing thus solves

$$\underset{p_t(\omega)}{Max} \mathrm{E}_t \sum_{s=t}^{\infty} \beta_{t,s} \left(p_s(\omega) y_s(\omega) \left(1 - \phi \left(p_s(\omega)/p_{s-1}(\omega) - 1 \right)^2 /2 \right) - mc_s y_s(\omega) \right), \phi \geq 0 \tag{12}$$

subject to the demand function given by Equation (7), which gives

$$(\eta - 1) \left(1 - \phi (\pi_t - 1)^2 /2 \right) + \phi \left(\pi_t (\pi_t - 1) - \mathrm{E}_t \left\{ \beta_{t,t+1} \pi_{t+1} (\pi_{t+1} - 1) y_{t+1}/y_t \right\} \right) = \eta mc^r_t \tag{13}$$

where $mc^r_t = mc_t/p_t$ is the real marginal cost in the retail sector.

The production sector is made of intermediate goods producers and final goods producers. In the intermediate sector, a unit mass of producers use labor to produce an intermediate input that they sell competitively. Their production function is

$$x_t = a_t \ell_t \tag{14}$$

where a_t is a measure of sectoral productivity that evolves as an AR(1) process: $\log a_t = \rho_a \log a_{t-1} + \epsilon^a_t$. The CPI-based real marginal cost φ_t at which intermediate output is sold is

$$\varphi_t = \frac{(1 + \tau_{\ell t})(w_t/p_t)}{a_t} \tag{15}$$

as hiring units of labor incurs the payment of a payroll tax $\tau_{\ell t}$.

In the final good sector, there is a continuum of heterogeneous firms that differentiate intermediate goods. The sector allows for endogenous entry and endogenous tradability. Over the

[8] As will become clear in the next section, n_t varieties are produced in the domestic economy (resp. n^*_t in the foreign economy) and only a subset $n_{x,t}$ (resp. $n^*_{x,t}$) of the total number of varieties is actually traded.

entire space of potential varieties, only a subset will actually be created and commercialized. Firms have specific random productivity draws z that remain fixed once firms have been created. Variety creation incurs a once and for all sunk cost f_e, paid in units of intermediate goods. At each period t, there are two types of firms: n_t firms that are already productive at the beginning of the period and $n_{e,t}$ firms that are newly created – but nonproductive yet – within the period. At the end of the period a fraction $\delta \in [0,1]$ of all existing firms is exogenously affected by an exit shock. The total number of varieties thus evolves according to:

$$n_t = (1-\delta)(n_{t-1} + n_{e,t-1}) \tag{16}$$

Among the firms created, only the most productive address the export market. Entry in the export market is subject to the repeated payment of a cost f_x, also paid in units of intermediate goods, and incurs the payment of iceberg melting costs τ.[9] Firm-specific productivity z has a Pareto distribution with lower bound $z_{\min}$ and shape parameter $\varepsilon > \theta - 1$. The probability density function of z is $g(z) = \varepsilon z_{\min}^{\varepsilon}/z^{\varepsilon+1}$ and the cumulative density function is $G(z) = 1 - (z_{\min}/z)^{\varepsilon}$. Over the total number of potential firms, only a proportion n_t will actually be created

$$n_t = 1 - G(z_{d,t}) = (z_{\min}/z_{d,t})^{\varepsilon} \leq 1 \tag{17}$$

where $z_{d,t}$ will be determined by a free-entry condition. In addition, among the total number of firms addressing the local market, the number of exporting firms $n_{x,t}$ will be those that are productive enough to cover the additional various export costs and their number is:

$$n_{x,t} = (1 - G(z_{x,t}))\, n_t = (z_{\min}/z_{x,t})^{\varepsilon}\, n_t \tag{18}$$

where $z_{x,t}$ is the individual productivity of the cut-off exporting plant. Let $\kappa_t(z)$ denote the total current profits of a firm with productivity z and $\varphi_t(z) = \varphi_t/z$ its specific production cost. Total current profits are composed of domestic and export profits, $\kappa_{d,t}(z)$ and $\kappa_{x,t}(z)$:

$$\kappa_{d,t}(z) = \left(\frac{p_{d,t}(z)}{(1+\tau_{vt})\,p_t} - \frac{\varphi_t}{z}\right) y_{d,t}(z) \;\text{ and }\; \kappa_{x,t}(z) = \left(\frac{p_{x,t}(z)}{(1+\tau_{vt}^{*})\,p_t} - \frac{(1+\tau)\,\varphi_t}{z}\right) y_{x,t}(z) - f_x\varphi_t \tag{19}$$

where τ_{vt} and τ_{vt}^{*} are respectively the domestic and foreign VAT rates.[10] Optimal pricing conditions are derived subject to the demand function given by Equations (10)-(11) and optimal prices imply

$$\rho_{d,t}(z) = \frac{p_{d,t}(z)}{p_t} = \mu(1+\tau_{vt})\frac{\varphi_t}{z} \;\text{ and }\; \rho_{x,t}(z) = \frac{p_{x,t}(z)}{p_t^{*}} = (1+\tau)\,\mu(1+\tau_{vt}^{*})\frac{\varphi_t}{q_t z} \tag{20}$$

[9] Out of a quantity y produced and shipped, only $y/(1+\tau)$ actually arrives. Firms need to produce $(1+\tau)\,y$ to sell y.

[10] Notice that the foreign VAT rate applies to the exports of domestic firms.

where we have used the fact that $q_t = p_t^* / p_t$ is the real exchange rate and where $\mu = \theta / (\theta - 1)$. Entry occurs one period before production can start and the productivity draw of the last entering firm is fixed until the corresponding firm exits. The firm does not know its productivity draw before entry. Hence, the entry condition equates the current entry cost, expressed in units of the intermediate good, to the total (domestic and export) discounted expected profits (starting in $t+1$) made by the average incumbent. The corresponding entry condition writes

$$\mathrm{E}_t \left\{ \sum_{s=t+1}^{\infty} \left(\beta_{t,s} (1-\delta) \right)^{s-t} \widetilde{\kappa}_s \right\} = f_e \varphi_t \tag{21}$$

where average profits $\widetilde{\kappa}_t$ will be defined in Section 2.4. After expressing the condition recursively, we get

$$\mathrm{E}_t \left\{ \beta_{t,t+1} (1-\delta) \left(\widetilde{\kappa}_{t+1} + f_e \varphi_{t+1} \right) \right\} = f_e \varphi_t \tag{22}$$

This equation is very similar to Ghironi & Melitz (2005), except that the entry sunk cost is paid in units of intermediate goods. It shows the determinants of firms' entry. Given the definition of profits, entry is high when current marginal costs are low, when domestic and export markets are large, and when the tax rates are low. The entry condition also shows that entry is high when current entry costs are low or expected discounted entry costs higher than current costs. Among the firms that produce, only the most productive can profitably enter the export market given that exporting requires the repeated payment of iceberg and sunk export costs. Hence the export productivity cut-off is $\kappa_{x,t}(z_{x,t}) = 0$ or, after using the optimal pricing and demand conditions,

$$z_{x,t} = \frac{(1+\tau)}{(\theta-1)} \left(\frac{\theta \left(1+\tau_{vt}^*\right) \varphi_t}{mc_t^{*r} q_t} \right)^{\frac{\theta}{\theta-1}} \left(\frac{f_x}{y_t^*} \right)^{\frac{1}{\theta-1}} \tag{23}$$

As in the case of firms' entry, the equation sheds light on the determinants of entry in the export market: low trade costs, low marginal costs, low fixed export costs, low foreign VAT and large foreign markets.

2.3 Aggregation, Policies and Data Consistency

Let us define the average productivity of firms addressing the domestic market as $\widetilde{z}_{d,t} = \nabla z_{d,t}$ where $\nabla = \left(\varepsilon / \left(\varepsilon - (\theta - 1) \right) \right)^{\frac{1}{\theta-1}}$ and the average productivity of firms addressing both markets as $\widetilde{z}_{x,t} = \triangledown z_{x,t}$. [11]

Average prices. Defining the average price of a domestic good as $\widetilde{\rho}_{d,t} = p_{d,t}(\widetilde{z}_{d,t}) / p_t$ and the

[11] Average productivity levels are defined as $\widetilde{z}_{d,t} = \left[\frac{1}{1-G(z_{d,t})} \int_{z_{d,t}}^{\infty} z^{\theta-1} dG(z) \right]^{1/(\theta-1)}$ and $\widetilde{z}_{x,t} = \left[\frac{1}{1-G(z_{x,t})} \int_{z_{x,t}}^{\infty} z^{\theta-1} dG(z) \right]^{1/(\theta-1)}$. See Ghironi & Melitz (2005) for a discussion and Melitz (2003) for proofs.

average price of an exported good as $\widetilde{\rho}_{x,t} = p_{x,t}\left(\widetilde{z}_{x,t}\right)/p^*_t$, we obtain real average prices:

$$\widetilde{\rho}_{d,t} = \mu\left(1+\tau_{vt}\right)\varphi_t/\left(\triangledown z_{d,t}\right) \text{ and } \widetilde{\rho}_{x,t} = \left(1+\tau\right)\mu\left(1+\tau^*_{vt}\right)\varphi_t/\left(q_t \triangledown z_{x,t}\right) \tag{24}$$

where $q_t = p^*_t/p_t$ is the real exchange rate.

Average profits. Using the profit and pricing equations, we get

$$\widetilde{\kappa}_{d,t} = \left(1-\mu^{-1}\right)\left(1+\tau_{vt}\right)^{-1}\widetilde{\rho}_{d,t}^{1-\theta}\left(mc^r_t\right)^{\theta} y_t \text{ and } \widetilde{\kappa}_{x,t} = \frac{\theta-1}{\varepsilon-(\theta-1)} f_x\varphi_t \tag{25}$$

These equations can be used to obtain the dynamics of average profits

$$\widetilde{\kappa}_t = \widetilde{\kappa}_{d,t} + (n_{x,t}/n_t)\widetilde{\kappa}_{x,t} \tag{26}$$

Variety effect. From the form of the marginal costs in the retail sector, we uncover the following variety effects:

$$n_t\widetilde{\rho}_{d,t}^{1-\theta} + n^*_{x,t}\widetilde{\rho}_{x,t}^{*1-\theta} = \left(mc^r_t\right)^{1-\theta}, \text{ and } n^*_t\widetilde{\rho}_{d,t}^{*1-\theta} + n_{x,t}\widetilde{\rho}_{x,t}^{1-\theta} = \left(mc^{*r}_t\right)^{1-\theta} \tag{27}$$

Aggregate productivity. Beyond productivity in the intermediate goods sector a_t, aggregate productivity is also affected by composition changes between our heterogeneous final goods producers, even for a fixed and given distribution of productivity draws. Whether aggregate productivity in the final goods sector is computed based on the density function $g(z)$ or, as in Melitz (2003), based on weights reflecting relative output shares, entry and exit on domestic and export markets will affect the aggregate productivity level. We follow Melitz (2003) and define two measures of aggregate productivity, one for all domestic final goods producers and one for final goods producers that export:

$$Z_{d,t} = n_t^{1/(\theta-1)}\widetilde{z}_{d,t} \text{ and } Z_{x,t} = n_{x,t}^{1/(\theta-1)}\widetilde{z}_{x,t} \tag{28}$$

These equations show that aggregate productivity may increase either because the average productivity level rises, or because of a scale effect by which there are more producers on the markets. Because, both arguments are negatively related through Equations (17)-(18), the interaction is *a priori* unknown. However, given that ε will be relatively large (see calibration in Section 3), the positive impact of having a larger number of firms should dominate. For instance, any change in the environment leading to a fall in the productivity threshold will lower the average productivity level and boost business creation. This will raise the number of producers, and in turn, increase aggregate productivity.[12]

Goods market clearing. Intermediate goods serve as inputs of final goods producers. When final

[12]The positive effect of entry on productivity has been documented empirically by Melitz & Polanec (2015) or Gourio, Messer & Siemer (2016), although the mechanisms suggested in these contributions are somehow different from the channel uncovered by our model.

goods producers are more efficient they need less intermediate input to address the demand from the retail sector. Further, the various entry costs are paid in units of intermediate goods. The market clearing condition is thus

$$a_t \ell_t = \left(\frac{mc_t^r}{\widetilde{\rho}_{d,t}} \right)^\theta \frac{n_t y_t}{\nabla z_{d,t}} + (1+\tau) \left(\frac{mc_t^{r*}}{\widetilde{\rho}_{x,t}} \right)^\theta \frac{n_{x,t} y_t^*}{\nabla z_{x,t}} + n_{e,t} f_e + n_{x,t} f_x \tag{29}$$

The market clearing condition for the final goods sector is

$$y_t^c = n_t \left(mc_t^r \right)^\theta \widetilde{\rho}_{d,t}^{1-\theta} y_t + n_{x,t} \left(mc_t^{r*} \right)^\theta \widetilde{\rho}_{x,t}^{1-\theta} y_t^* \tag{30}$$

Net foreign assets. Net foreign asset dynamics is obtained aggregating all budget constraints (domestic households, government, intermediate and final goods producers) and combining with market clearing conditions:

$$b_t^r - r_{t-1} b_{t-1}^r / \pi_t = q_t n_{x,t} \left(mc_t^{r*} \right)^\theta \widetilde{\rho}_{x,t}^{1-\theta} y_t^* - n_{x,t}^* \left(mc_t^r \right)^\theta \widetilde{\rho}_{x,t}^{*1-\theta} y_t \tag{31}$$

Inflation rates. Finally, using the definition of average prices, the dynamics of domestic and export goods inflation rates is given by

$$\pi_{d,t}/\pi_t = \widetilde{\rho}_{d,t}/\widetilde{\rho}_{d,t-1} \text{ and } \pi_{x,t}/\pi_t^* = \widetilde{\rho}_{x,t}/\widetilde{\rho}_{x,t-1} \tag{32}$$

Governments. Governments have a balanced budget every period. Distorsionary and lump-sum taxes exactly finance public expenditure g_t, expressed in units of final goods

$$\tau_{\ell t} \left(w_t / p_t \right) \ell_t + \tau_{ct} c_t + \left(\tau_{vt} / \left(1 + \tau_{vt} \right) \right) mc_t^r y_t + tax_t = g_t \tag{33}$$

Our exercises assume that public spending remain constant, *i.e.* $g_t = g$.

Monetary Policy. Given our monetary-union set-up and our assumption of sticky prices, the monetary policy followed by the central bank affects real interest rates in both countries. We assume that the common central bank controls the nominal interest rate, and commits to the following rule

$$\log \left(r_t / r \right) = \rho_r \log \left(r_{t-1} / r \right) + (1 - \rho_r) \left(d_\pi \log \left(\widetilde{\pi}_t^u \right) + d_y \log \left(\widetilde{y}_t^u / \widetilde{y}_{t-1}^u \right) \right) + \epsilon_t^r \tag{34}$$

where $\widetilde{\pi}_t^u = \widetilde{\pi}_t^{1/2} \widetilde{\pi}_t^{*1/2}$ is the union-wide average (data-consistent) inflation rate and $\widetilde{y}_t^u = \widetilde{y}_t^{1/2} \widetilde{y}_t^{*1/2}$ is the data-consistent output.

Data consistency. As explained in Ghironi & Melitz (2005), our model variables have to be deflated by a price index capturing the aggregate variety effect. Indeed, in the presence of endogenous varieties and when household preferences exhibit love for variety, the welfare-based price index may vary even though product prices remain fixed. In addition, the official statistics for price indices and real aggregates consider the number of varieties as fixed and update the range of good varieties on a rather infrequent basis while the number of varieties changes every period in our model. Hence, we define macroeconomic aggregates and prices in a way that is consistent with the data. Defining $\widetilde{p}_t = (n_t + n_{x,t})^{\frac{1}{\theta-1}} p_t$, as a deflator that takes into account the total number of varieties, any real data-consistent aggregate x_t writes $x_t^r = p_t x_t/\widetilde{p}_t$. Along the same lines, we define the average data-consistent inflation rate as $\widetilde{\pi}_t = \widetilde{p}_t/\widetilde{p}_{t-1}$, and the data-consistent real exchange rate is $\widetilde{q}_t = \widetilde{p}_t^*/\widetilde{p}_t$. Finally, data-consistent trade flows (exports and imports) are computed using deflators that take into account the relevant number of traded varieties. The data-consistent trade balance is defined as data-consistent exports minus data-consistent imports divided by data-consistent GDP.

2.4 Inefficiency wedges

As in recent contributions like Cacciatore & Ghironi (2014), we characterize the inefficiencies implied by our decentralized economy by comparing the efficient allocation with the decentralized allocation described above. This will help us understand the efficiency gains or losses implied by the tax reforms considered in the next sections.[13] We denote these wedges with an Υ and define them so that their value is zero when the economy is efficient.

Pricing wedges. Our model features two tax rates and monopolistic competition in the final good sector. As such, the pricing conditions are distorted. First because tax rates (VAT and the payroll tax) introduce a wedge between the marginal rate of substitution between leisure and consumption and the real wage paid to the workers, and second because monopolistic final goods producers apply a mark-up over their marginal cost. In each country, final goods producers optimally choose two prices (one for domestic goods and one for export goods), which leads us to identify four pricing wedges. Each of these wedges is of the form $\Upsilon_{\rho,t} = (\theta/(\theta-1))(1+\tau_{vt})(1+\tau_{\ell t}) - 1$ where the VAT and payroll tax rates are either the domestic or foreign rates depending on where the goods are produced and which market is addressed. These wedges are decreasing in the intensity of competition (when θ goes up) and fall when tax rates fall. In the limit case where tax rates are zero and competition is perfect, the wedges are null and the decentralized pricing conditions on final goods markets match the efficient pricing conditions. These wedges will matter crucially because they influence entry conditions on domestic and export markets, and because they are significantly affected by the tax reforms.

Marginal cost wedges. In the retail sector, our model assumes monopolistic competition and sticky prices. Monopolistic competition induces a steady-state distortion that depends on the steady-state mark-up $\eta/(\eta-1)$. Sticky prices induce temporary deviations of the mark-up from its steady-state value. These distortions matter because they modify the total demand for final

[13] Appendix B shows how the inefficiency wedges are computed.

goods, therefore indirectly affecting the extent of domestic and export entry conditions, and tailoring the size of total private demand in the economy. The domestic and foreign marginal cost wedges are $\Upsilon_{MC,t} = 1 - mc_t^r$ and $\Upsilon^*_{MC,t} = 1 - mc_t^{r*}$ and the size of their fluctuations depends on the volatility of inflation rates (see Equation (13)).

Demand wedges. The decentralized economy features useless public spending, generating a demand of retail goods. In addition, portfolio adjustment costs are paid in terms of the retail goods. However, these demands are absent from the efficient allocation. Hence, they represent a distortion defined as $\Upsilon_{D,t} = g_t + ac_{b,t}$.[14]

Risk-sharing wedge. Our model assumes incomplete international asset markets. This asset structure is known to generate inefficient real exchange rate fluctuations in comparison to the efficient (complete) asset market structure. As such the risk-sharing wedge $\Upsilon_{RS,t} = u^*_{c,t}/u_{c,t} - q_t$ measures the lack of risk-sharing. Given that we consider a symmetric steady-state, the wedge will be zero in the steady state and will vary in the event of shocks.

Monetary union. The fact that our model is one of a monetary union and that the nominal exchange rate is fixed represents an inefficiency. However, the latter can not be expressed in terms of wedges since the efficient allocation is expressed in real terms only. As such, the monetary union inefficiency relates to the fact that, in the decentralized model, fluctuations in national inflation rates are addressed by only one monetary policy instrument while better outcomes might be achieved under a flexible exchange rate regime with two policy instruments.[15]

3 Calibration and business cycle moments

Calibration. The calibration is identical in both countries. Target countries are those that belong to the Euro Area. The model is quarterly. The discount factor is $\beta = 0.99$. The utility function is:

$$u(c_t, \ell_t) = \frac{\left(c_t^{\chi} (1 - \ell_t)^{1-\chi}\right)^{1-\gamma}}{1 - \gamma} \tag{35}$$

The risk-aversion parameter is set to $\gamma = 2$ and the value of χ is adjusted to obtain a steady-state value of hours worked of $\ell = 0.35$, in line with the share of hours worked in total awake time in Euro Area countries according to OECD figures. In the production sector, the values of f_e and f_x are determined endogenously to match respectively a given steady-state number of varieties n and a given number of traded varieties n_x. Without loss of generality, we impose $n = 0.9$. Based on European data from the SDBS Database, firms' death rate is consistent with

[14] We do not provide too many details on these wedges since they will be almost unaffected by our reforms – public spending remains constant and the adjustment cost component of the wedges is infinitesimal.

[15] We do not discuss this distortion too much since our reforms will not affect it. See Cacciatore, Fiori & Ghironi (2016) for a detailed discussion of this wedge, and Auray & Eyquem (2014) for a general discussion of monetary unions as second-best environments.

$\delta = 0.025$. Further, we follow Cacciatore et al. (2016) and calibrate the elasticity of substitution between varieties at $\theta = 3.8$.[16] We also follow Cacciatore et al. (2016) and set the price stickiness parameter to $\phi = 80$.

In the trade sector, we impose the share of exporting firms in the steady state at $n_x/n = 0.2$ based on French data (see Berman, Martin & Mayer (2012)), and adjust the export cost f_x accordingly. Eaton, Kortum & Kramarz (2011) estimate Pareto parameters governing the distribution of French firms and their best estimate is $\varepsilon = 4.87$. We impose this precise value, and choose the value of the iceberg cost parameter $\tau = 0.25$ to match the observed degree of (data-consistent) intra-zone trade openness for the Euro Area (29%). Our calibration implies that exporters are 36.19% more productive than non-exporters, and that domestic prices are 8.95% higher than export prices. Finally, as in Ghironi & Melitz (2005), the international bond adjustment cost parameter is $\phi_b = 0.0025$.

Our analysis will be conducted through changes in the VAT rate and in the payroll tax rate. The steady-state VAT rate is $\tau_v = 0.15$ and the steady-state payroll tax rate is $\tau_\ell = 0.30$. Both figures match Euro Area averages. The steady-state share of public spending in final output is $s_g = 0.2$ and the corresponding level of public spending remains fixed $g_t = g$. Monetary policy parameters are calibrated using the values reported by Cacciatore et al. (2016): $\rho_r = 0.87$, $d_\pi = 1.93$ and $d_y = 0.075$. Table 1 reports the value of our calibrated parameters.

Table 1: Parameter values.

Discount factor	$\beta = 0.99$
Risk-aversion	$\gamma = 2$
Consumption / leisure weight	χ adjusted to get $\ell = 0.35$
Entry cost	f_e adjusted to get $n = 0.9$
Export cost	f_x adjusted to get $n_x/n = 0.2$
Exogenous death rate	$\delta = 0.025$
Elasticity of substitution between varieties of final goods	$\theta = 3.8$
Elasticity of substitution between varieties of retail goods	$\eta = 6$
Pareto curvature parameter	$\varepsilon = 4.87$
Price stickiness parameter	$\phi = 80$
Steady-state trade costs	$\tau = 0.25$
Portfolio adjustment costs on bonds	$\phi^b = 0.0025$
Steady-state VAT rate	$\tau_v = 0.15$
Steady-state payroll tax rate	$\tau_\ell = 0.3$
Nominal interest rate persistence	$\rho_r = 0.87$
Reaction to aggregate data-consistent inflation	$d_\pi = 1.93$
Reaction to aggregate data-consistent output growth	$d_y = 0.075$

Business cycle moments. In this paragraph, we generate artificial business cycles moments with our model and compare them to the business cycle moments of the data. Fluctuations are

[16] Incidentally, a value of $\theta = 3.8$ implies rather high steady state markups over marginal costs. However, given the presence of fixed costs, markups over average costs are in line with values found in the literature. See Bilbiie, Ghironi & Melitz (2008) for an extensive discussion.

generated by productivity and monetary policy shocks. We set the persistence of productivity shocks at $\rho_a = 0.9$ and impose $std\,(\epsilon^a) = 0.6\%$ with a cross-country correlation of productivity innovations $\rho\left(\epsilon^a, \epsilon^{a^*}\right) = 0.5$. We then adjust the volatility of monetary policy shocks to match the absolute volatility of GDP, which implies $std\,(\epsilon^r) = 0.34\%$. Using this calibration and the parameters reported in Table 1, we solve the model using a first-order approximation around the deterministic steady state, and compare the business cycle moments computed on simulated HP-filtered time series – using a filtering parameter $\lambda = 1600$ – to the business cycle moments computed on observed HP-filtered time series.

Table 2: Business cycle moments.

	Data				Model			
Variable (x)	$\sigma(x)$	$\rho(x)$	$\rho(x, y^r)$	$\rho(x, x^*)$	$\sigma(x)$	$\rho(x)$	$\rho(x, y^r)$	$\rho(x, x^*)$
GDP (y_t^r)	1.34	0.88	–	0.93	1.34	0.63	–	0.61
Consumption (c_t^r)	0.67	0.74	0.63	0.71	0.90	0.55	0.80	0.97
Investment (i_t^r)	2.44	0.83	0.87	0.85	4.03	0.67	0.82	0.33
Employment (ℓ_t)	0.60	0.90	0.63	0.81	0.75	0.59	0.95	0.72
Exports	3.21	0.84	0.85	0.95	1.98	0.55	0.63	0.98
Imports	3.07	0.84	0.83	0.92	1.97	0.55	0.62	0.98
Net exports / GDP	0.13	0.65	0.20	0.61	0.10	0.92	0.04	–
Terms of trade $(\widetilde{q}_t)$	1.82	0.82	-0.41	0.97	0.02	0.63	-0.42	–
Entry $(n_{e,t})$	3.46	0.88	0.37	0.38	4.53	0.67	0.80	0.32
$\rho(n_{e,t}, \ell_t)$	0.31				0.59			

Note: $\sigma(x)$ is the standard deviation (for GDP and terms of trade) or the standard deviation relative to GDP (for consumption, investment, export, imports and net exports to GDP). $\rho(x)$ is the first-order correlation. $\rho(x, y)$ is the contemporaneous correlation with GDP. $\rho(x, x^*)$ is the correlation of a variable with the same variable in the rest of the monetary union.

Table 2 shows that the model correctly reproduces several features of the data.[17] As in the data, consumption is less volatile than GDP while investment is more volatile. Exports and imports are more volatile than GDP, but a little less so than in the data. The volatility of net exports to GDP is well matched. The volatility of terms of trade is much lower than in the data: as in Ghironi & Melitz (2005), the model does not fully reproduce the observed volatility of the real exchange rate. The relative volatility of firms' entry is well accounted for. Autocorrelations are too low compared to the data but cyclical patterns are broadly correctly matched. In particular, exports and imports are positively correlated with output and imports are less strongly correlated with output, generating slightly pro-cyclical net exports, as in the data.[18] The real exchange rate shows counter-cyclical movements and firms' entry is pro-cyclical, as in the data. The cross-

[17] Appendix A provides a complete description of the data used to compute the business cycle moments.

[18] Net exports are usually slightly counter-cyclical in the data. Our sample shows slightly pro-cyclical net exports. We believe that this result is driven by the post-euro pattern of capital flows inside the Euro Area and by the underlying Euro Area heterogeneity. Indeed, when disaggregating this cyclical pattern, we find that net exports are slightly counter-cyclical for France, and strongly counter-cyclical for Ireland, Spain and Portugal at the business cycle frequency. Other countries of the Euro Area, Germany in particular, feature pro-cyclical net exports. These contrasted cyclical patterns result in slightly pro-cyclical net exports at the aggregate level.

country correlations are large, although that of consumptions is too large and those of GDPs and of investments are too low compared to the data. The cross-country correlation of firms' entry is correctly reproduced, and the cross-country correlation of trade flows is almost that of the data. Finally, the correlation of firms' entry with hours worked is positive and a bit too large.

Overall, given its relative simplicity with respect to medium-scale business cycle models – we abstract from many assumptions like habits in consumption, price indexation, wage rigidity, and focus on a much scarcer number of driving shocks – the model performs rather well and correctly matches a wide range of business cycle moments. The model performs quite well in matching the business cycle moments pertaining to gross and net trade flows and those of firms' entry. In addition, it produces reasonable figures for business cycle moments of other relevant macro aggregates like GDP, consumption, employment or investment. We thus consider the model as providing a reliable business cycle representation of countries of the Eurozone, that we consider in our analysis of competitive tax reforms.

4 The effects of competitive tax reforms

In this section, we provide a detailed analysis of the effects of competitive tax reforms, as well as of their impact in terms of welfare and check the robustness of our results.

4.1 Baseline case

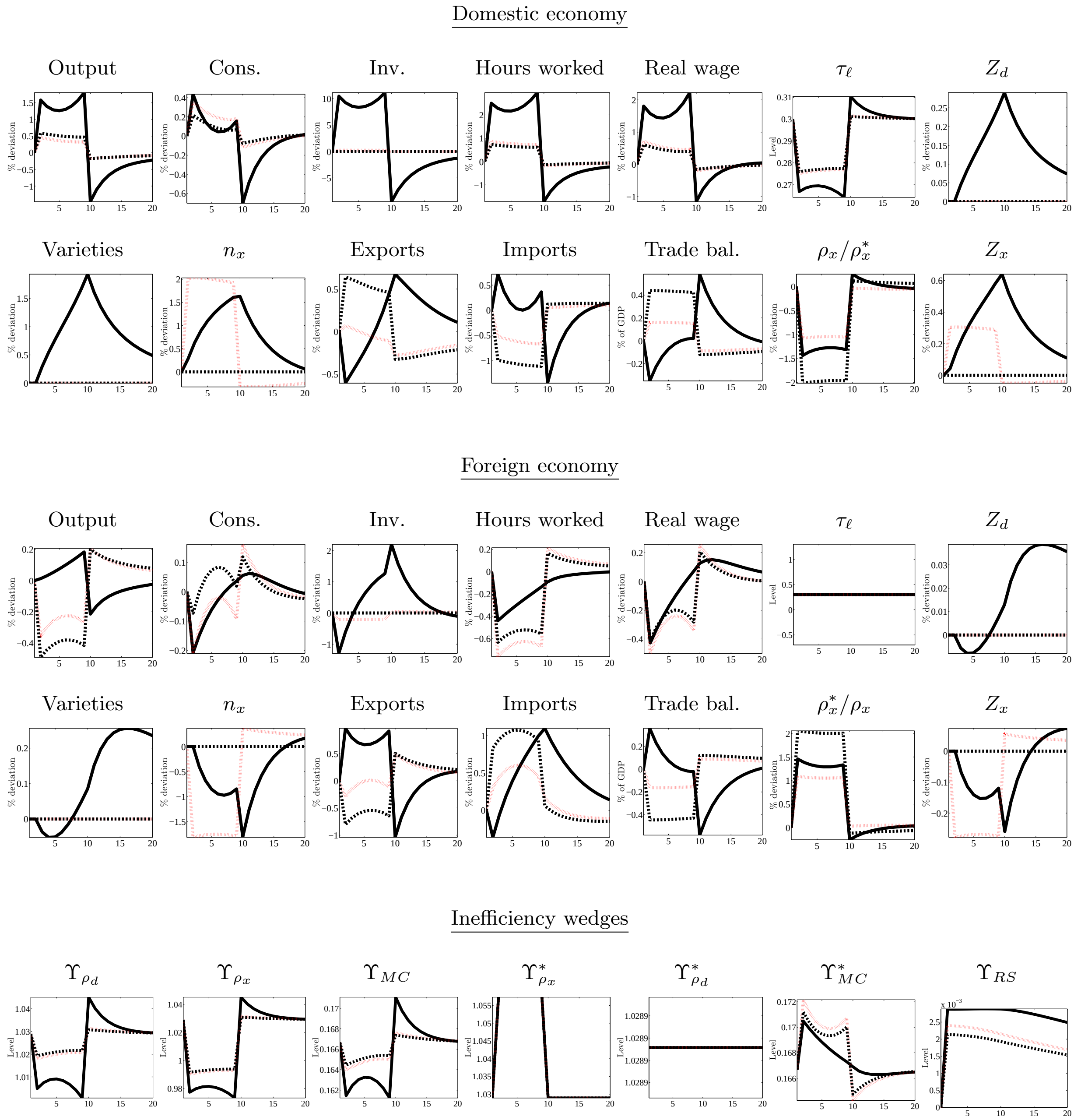
We start our analysis with the effects of a temporary (8 quarters) reform in the domestic economy. The government increases VAT $\Delta\tau_{vt} > 0$ in a way that raises fiscal receipts by 1 pp of *ex-ante* GDP, and cuts the payroll tax rate $\Delta\tau_{\ell t}$ in a way that keeps the budget balanced each period. The corresponding increase in VAT is 1.61pp, that will translate into a roughly 3pp fall in the payroll tax rate.

Figure 1 considers the response of the economy under three alternative models: the baseline model, the model with a constant number of produced varieties and the model with constant produced and traded varieties. When the number of produced varieties is constant, Equation (22) and its foreign equivalent are replaced by $n_t = n_t^* = n = 0.9$. When the number of traded varieties is constant, Equation (23) and its foreign equivalent are replaced by $n_{x,t} = n_{x,t}^* = n_x = 0.2n$. In all cases, the model is solved under perfect foresight using a non-linear Newton-type algorithm with the set of parameter values reported in Table 1.[19]

Let us start with the baseline model and focus on the domestic economy. The tax reform implies a rise in VAT and a fall in the payroll tax rate, with opposite effects on consumption. On the one

[19]The algorithm is a built-in routine of Dynare. It is an application of the Newton-Raphson algorithm that takes into consideration the special structure of the Jacobian matrix in dynamic models with forward-looking variables. The details of the algorithm are explained in Juillard (1996).

Figure 1: The effects of a domestic competitive tax reform



Solid black: baseline model, Dotted red: fixed n, Dashed black: fixed n and n_x. Variables are reported in a data-consistent manner unless specified otherwise.

hand, the rise in VAT increases the price of domestically produced goods as well as the price of imports, which tends to depress consumption. On the other hand, the fall in the payroll tax rate lowers the production cost of intermediate goods, which increases output and labor demand, and pushes the real wage up. The subsequent drop in marginal costs fosters business creation (the extensive margin) while the rise of labor income potentially contributes to the intensive margin of consumption. Overall, welfare-based consumption goes up mostly due to the contribution of the extensive margin and data-consistent consumption (the intensive margin of consumption) is roughly muted in the first periods before rising as well. The dynamics of varieties is interpreted through Equation (22). The latter shows that the reform has potentially opposite effects on firms' entry: the rise in VAT should depress business creation by lowering domestic profits while the fall in the marginal production cost and the rise in (welfare-based) domestic demand should raise profits and therefore push entries in the opposite direction. In equilibrium, the second effect dominates and the total number of varieties rises significantly, driving investment up as well. As a corollary, average productivity, that depends on the entry threshold, falls because less productive firms enter the market. However, aggregate productivity rises because the number of firms – the scale effect – on the market more than compensates the fall in average productivity. Last, the net effect on (data-consistent) output is positive because total demand – data-consistent consumption plus investment in the creation of new ventures – goes up.

In the export sector, the trade reform has unambiguously positive effects on the number of exporters and on the relative price of exported goods. The latter falls because the marginal production cost falls, and the export entry threshold falls as well, pushing more firms to address the export market. The net effect on export flows is mixed however because the transmission to foreign consumption is negative in the very first periods before turning positive. Total exports follow a similar pattern, they fall initially (for 6 quarters) before rising along with foreign demand. The dynamics of imports can be read through the rise in their relative price, that depresses them, and the rise in domestic welfare-based consumption, that stimulates them. The second effect dominates and imports rise in the first periods. As a result, the net effect on the trade balance is negative for 6-7 quarters before the boost in exports overturns the rise in imports and generates a small trade surplus. Quantitatively speaking, a relatively small competitive tax reform raises output by 1.5% on impact, and by more than 1.8% after 8 quarters. It increases (data-consistent) consumption by 0.4% on impact, and raises hours worked by roughly 2.5%. The real wage increases by roughly 1.8% on impact and the number of firms goes up progressively to reach a 1.8% deviation from its initial value after 9-10 quarters.

What assumptions are key in generating our results and why do they matter? Comparing the baseline model with the other two models suggests that the key assumption is endogenous entry rather than endogenous tradability. Indeed, compared to the other two models, the baseline model produces magnified dynamics of output, real wage, hours worked, and consumption, and changes the response of trade flows to the competitive reform. In contrast, when the total number of varieties is fixed (and tradability endogenous or constant), the dynamics of most macroeconomic variables are very similar.

First, when the total number of varieties is endogenous, the competitive tax reform not only increases the intensive margin of consumption and output, but it also boots domestic business creation, the extensive margin. This contributes to magnify the response of output, hours worked and wages. Second, and equally important in our view, the transmission of the shock to the foreign economy changes from negative to positive when the total number of varieties is endogenous rather than fixed. This also changes qualitatively the responses of trade flows. When the number of varieties is fixed, the fall in the relative price of domestic exports triggers an expenditure switching effect toward domestic goods. Facing this demand slowdown, foreign firms cut their production and demand less labor, which reduces both hours worked and real wages. Foreign exports fall and foreign imports rise which lowers the trade balance and depresses output. When the total number of varieties is endogenous, the transmission to the foreign economy is clearly positive. Indeed, the fall in the foreign real wage generates a positive spillover, as it lowers the foreign entry cost. Business creation is boosted, which turns the response of foreign output from negative to positive. In addition, because endogenous variety creation magnifies the rise in domestic consumption, the foreign export threshold falls, pushing more firms to enter the export market, and foreign exports rise (instead of falling with constant varieties). This rise in foreign exports mirrors the rise in domestic imports already mentioned above. Crucial to our result is thus the joint dynamics of business creation and trade balances, that heavily rely on the joint dynamics of market sizes and real marginal production and entry costs.

Overall, assuming endogenously produced varieties makes a significant difference both quantitatively and qualitatively for the dynamics of key domestic variables after a competitive tax reform. The assumption of endogenous tradability makes a smaller difference on those variables. Endogenous business creation matters because it changes the foreign transmission of competitive tax reforms from negative to positive. Indeed, competitive tax reforms are usually perceived as aggressive, *beggar-thy-neighbor* policies. This is true when the number of produced varieties is constant. However, our model shows that, when taking endogenous business formation into account in a realistic general equilibrium model, competitive tax reforms induce output gains both for the domestic economy and for trade partners. In this environment, the reform increase trade flows, output, consumption and investment in both countries, making them *prosper-thy-neighbor* policies in terms of economic activity. Opposite conclusions are obtained in models with a constant number of produced varieties.

4.2 Welfare analysis

Given the above dynamics, what will be the welfare implications of the tax reform analyzed? We quantify the welfare gains by computing the Hicksian consumption equivalent that makes households indifferent between experiencing the reform and remaining at the initial steady state. This Hicksian equivalent is computed at different horizons, for the three models. Its calculation is made using the utility function with simulated paths for welfare-based consumption and hours worked. The most relevant computation is the one that is made over an infinite horizon but the associated numbers should be small since the reform is temporary and lasts only 8 quarters. In the short run, in the domestic economy, the tax reform raises hours worked and welfare-based consumption, a combination that yields unclear welfare effects. In the longer run, consumption remains above its steady-state value for quite some time while hours worked fall below their steady-state value, so the reform should generate welfare gains. In the foreign economy, the short-run and long-run welfare effects should be positive given the joint increase in consumption and fall in hours worked. How big are these welfare gains/losses? Do alternative models produce different welfare effects?

Table 3: Welfare effects of competitive tax reforms, in percents

	Baseline			Cst. n			Cst. n and n_x		
Horizon	Dom.	For.	Agg.	Dom.	For.	Agg.	Dom.	For.	Agg.
1	−0.5971	0.0475	−0.2748	−0.1584	0.2017	0.0216	−0.1279	0.1682	0.0202
4	−0.9254	0.1139	−0.4077	−0.2824	0.3682	0.0421	−0.2300	0.3070	0.0382
8	−1.0628	0.1603	−0.4540	−0.3353	0.4204	0.0415	−0.2746	0.3506	0.0373
32	−0.0745	0.1049	0.0152	−0.0624	0.0844	0.0109	−0.0545	0.0751	0.0103
60	−0.0105	0.0503	0.0199	−0.0225	0.0353	0.0064	−0.0211	0.0332	0.0061
∞	0.0027	0.0177	0.0102	−0.0062	0.0125	0.0031	−0.0064	0.0123	0.0030

Note: A negative sign indicates a welfare loss.

Table 3 shows that a temporary competitive tax reform generates a 0.60% welfare loss for domestic households on impact and a small 0.047% gain for foreign households in the baseline model. After 8 quarters, the welfare effects are amplified both for domestic and foreign households. Over the medium run (32 quarters), the reform has long been undone – remember, in quarter 8 – but still affects households welfare. Undoing the reform generates an instantaneous welfare gain for domestic households, that contributes to lower the intertemporal contribution of the initial loss. Hence, after 32 quarters, domestic households still endure a 0.075% welfare loss and foreign households experience a 0.105% welfare gain. Taking into account the full transition path (∞ line of Table 3) delivers the *true* lifetime welfare impact of the reform. Its positive effects go through the extensive margin of output and trade flows and generate small *welfare gains for everyone* (0.0027% in the home economy and 0.0177% in the foreign economy). While these numbers might seem small, it should be recalled that the total welfare losses from business cycle fluctuations in this kind of models is rarely larger than 0.01% or 0.02% of consumption equivalent. Looking at aggregate welfare, the welfare benefits from an 8-quarters temporary tax reform are roughly equivalent to the total welfare costs from business cycles.

Notice that alternative models, that feature a constant number of produced varieties, generate smaller welfare losses for the domestic households and larger welfare gains for the foreign households at short horizons. However, alternative models produce a lifetime welfare effect that is negative for the domestic households and positive but smaller for the foreign households. As such, they result in much smaller aggregate lifetime welfare gains compared to the baseline model. On the contrary, the total welfare gains from the competitive tax reform are larger with an endogenous number of varieties: small and positive for the domestic households (instead of negative in alternative models) and larger and positive for the foreign households (instead of small and positive in alternative models).

Looking at Figure 1 helps understand this result. Figure 1 shows that the efficiency gains from competitive tax reforms mostly channel through the pricing efficiency wedges and through the marginal cost wedges. In all models, the competitive tax reform lowers the payroll tax rate much more than the increase in VAT. As a consequence the tax wedge included in the pricing wedge goes down for the goods produced in the domestic economy, lowering Υ_{ρ_d} and Υ_{ρ_x}. For goods produced in the foreign economy, the pricing wedge of local goods $\Upsilon_{\rho_d^*}$ remains constant while that of foreign exported goods $\Upsilon_{\rho_x^*}$ goes up because domestic VAT, that applies to goods sold on domestic markets, goes up. The domestic retail good incorporates both domestic goods and foreign exported goods, hence combining a fall in the pricing wedge of the former and a (larger) rise in the pricing wedge of the latter, resulting in a *negative* impact welfare effect for the domestic households. The foreign retail good incorporates both foreign goods and domestic exported goods, hence combining a constant pricing wedge of the former and an unambiguous fall in the pricing wedge of the latter, resulting in a *positive* impact welfare effect for the foreign households. Figure 1 shows that efficiency improves a lot more – pricing wedges fall more – with an endogenous number of produced varieties, compared to alternative models. This generates larger welfare gains both for domestic and foreign consumers in the long run. This is particularly true for the pricing wedge of the domestic good, explaining the reversal in the true lifetime welfare effect of the competitive tax reform for the domestic households.

Another way of looking at the efficiency gains implied by the reform in the baseline model compared to alternative models is to look at aggregate productivity measures. Qualitatively, these measures are the mirror images of the number of producers respectively on local and export markets. Domestic and foreign aggregate productivity (Z_d and Z_d^*) both increase, accounting for the aggregate welfare gains, that also reflect the global efficiency gains. The aggregate productivity of domestic exporters (Z_x) increases a lot (more than the aggregate productivity of all domestic firms) and the aggregate productivity of foreign exporters (Z_x^*) falls. The efficiency gains associated with the former are incorporated in the foreign consumption bundle, while the efficiency losses from the latter are incorporated in the consumption bundle of domestic households, which explains the distribution of welfare gains and losses in the short run.

4.3 The stabilizing effects of competitive tax reforms

One may argue that competitive tax reforms make sense only when a distortion in the relative price of exports is observed. A stabilization or rebalancing of the terms of trade can be induced by a tax reform. In this section, we present the results of an experiment that somehow tracks the experiment proposed by Farhi et al. (2014). First, we feed the model with a shock that jointly raises the cost of borrowing in the domestic economy from 4% annually to 6.5%, and raises the entry costs by 6%. The joint shock will result in a fall in economic activity, a destruction of businesses and a rise in the relative price of domestic exports.[20] Second, we compute the effects of the same joint shock with a temporary competitive tax reform to investigate its stabilizing properties. The tax reform is a 5 pp rise in VAT with a fall in the payroll tax rate that keeps fiscal receipts constant.[21] Both cases are reported in Figure 2.

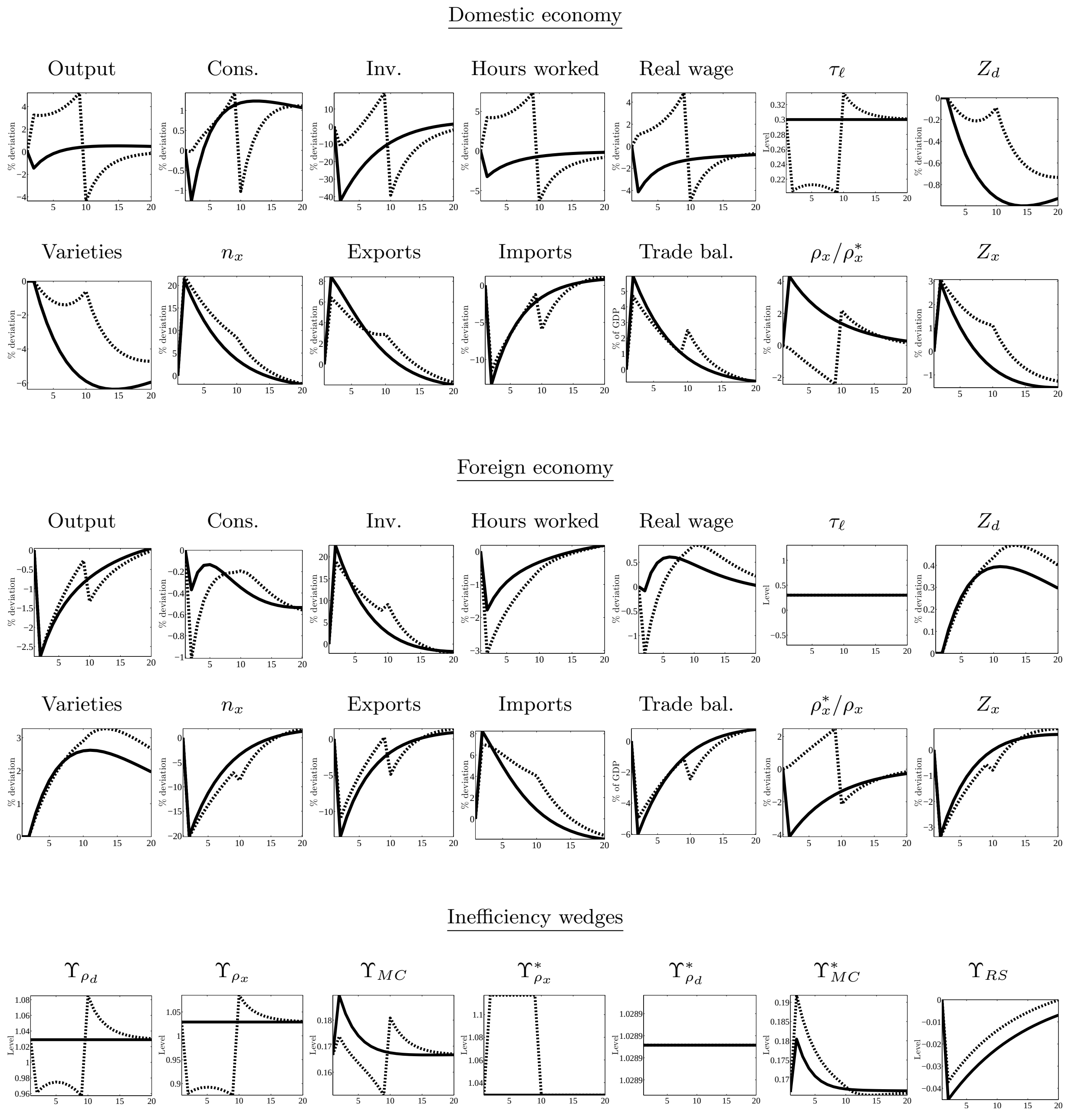
Figure 2 shows that the adverse shock in the domestic economy (dashed lines) produces a significant slump, lowering output by almost 2%, consumption by more than 1% and investment by more than 40%. The fall in output is clearly moderated by the fact that the shock generates a trade surplus of roughly 6% of GDP, driven by a massive drop in imports. Exports rise under the effect of a rise in the number of exported varieties, due to the positive transmission of the shock the extensive margin of foreign consumption. The dynamics of investment is driven by the fall in business formation, illustrated by the roughly 6% drop in total varieties. The joint shock drives the real wage down by almost 4%, which should *per se* result in a fall of terms of trade. However, because the domestic market shrinks a lot, the productivity threshold of foreign exporters rises sharply, which makes foreign export prices fall more than domestic export prices, resulting in a roughly 4% rise in terms of trade. Output falls in the foreign economy because of the rather large trade deficit, although investment and the extensive margin of consumption are stimulated. Overall, the domestic effects of the shock track relatively well the dynamics observed in countries of peripheral Euro Area (Spain for instance) during the 2011-2012 crisis.

Conditional on this shock, a 5pp rise in VAT combined with a fall in the payroll tax rate alters quite substantially the dynamics of the economy. First of all, the fall in the payroll tax rate is much larger than 5pp, around 12pp. Because VAT remains constant in the foreign economy, it produces an important fall in domestic export prices. In addition, the fall in the payroll tax rate produces a fall in the marginal production cost of the intermediate good, which boosts business creation (down by 1% instead of down by 6%), drives labor demand up and turns the response of output and investment from negative (without the competitive tax reform) to positive. The rise in output is almost 4% (instead of a roughly 4% fall) and the rise in investment peaks at 15% (instead of a roughly 40% fall). Real wages rise, which also turns the response of private consumption

[20] The shock affects the cost of borrowing and entry costs in the domestic economy only. We assume an AR(1) parameter equal to 0.95 to capture the persistence of the subsequent slump.

[21] We track the path of fiscal revenues implied by the joint shock only and impose this path as an exogenous variable when the shock is combined to a competitive tax reform to obtain the dynamics of the payroll tax rate.

Figure 2: Joint negative shock in the domestic economy with or without a domestic competitive tax reform



Solid black: Negative joint shock only, Dashed black: Negative joint shock with competitive tax reform. Variables are reported in a data-consistent manner unless specified otherwise.

from negative to positive. As a result of the dynamics of the marginal production cost, the relative price of exports goes down, indicating a significant rise in competitiveness instead of going down when the reform is absent. The consequences for the foreign economy are relatively minor as compared to the dynamics of the domestic economy. The foreign economy experiences a slightly larger fall in output, driven by the moderation in consumption and investment growth through the response of monetary policy. This moderate dynamics of output translates into a larger fall in labor demand and a larger fall in the real wage.

Overall, this type of reform stabilizes terms of trade and efficiently sustains economic activity in the country experiencing an adverse shock affecting borrowing and entry costs and the subsequent slump. Negative spillovers to the foreign economy are relatively limited in the short run and largely positive in the medium and long run. These results make competitive tax reforms potentially interesting policy instruments to counteract severe economic downturns that hurt the competitiveness of countries belonging to a monetary union.

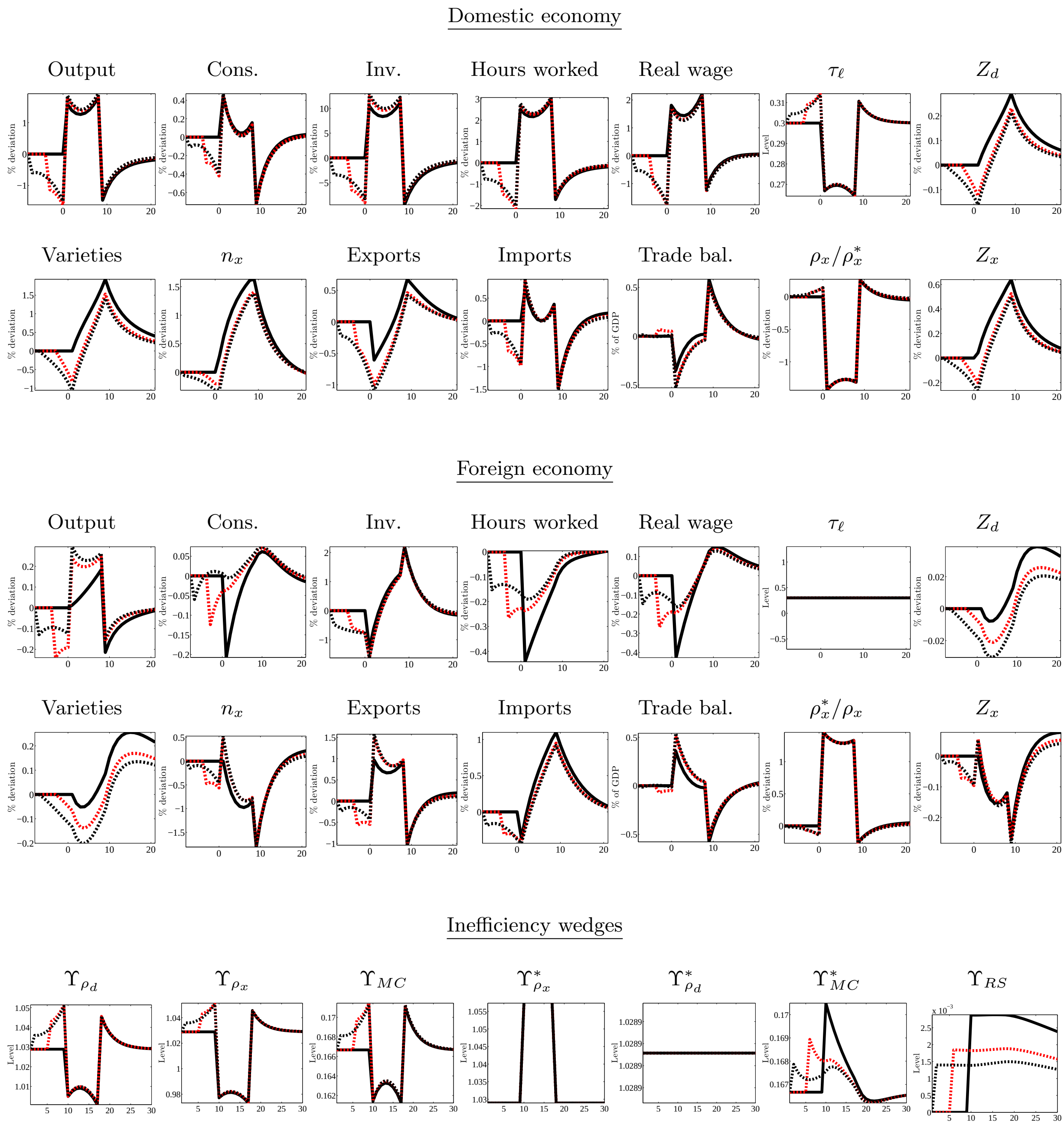
4.4 Unexpected vs. announced reform

We now investigate the extent to which the timing of announcement matters when implementing competitive tax reforms, given that most fiscal reforms are pre-announced. From the literature, we know that news shocks have very different implications than unexpected immediate shocks and this should also be the case here. Figure 3 reports the effects of a domestic competitive tax reform effective in period 1 announced 4 or 8 quarters ahead. It also reports the effects of an immediate and unexpected reform, as in Section 4.1.

Let us first focus on the domestic effects of pre-announced reforms. Within the quarter of the announcement, households and firms know for certain that VAT will rise and that the payroll tax will fall in 4 and 8 quarters respectively. The expected fall in the payroll tax lowers the future cost of building varieties – through the effect on the real wage – leading firms to postpone entry. Produced varieties thus fall immediately, leading the demand for intermediate goods to collapse as well, lowering labor demand (hours worked and the real wage both drop when the reform is pre-announced). These movements are large enough to lower consumption. Transmission to the foreign economy goes through the shrinking of the domestic market – foreign exports fall, impulsing negative dynamics for aggregate demand in the foreign economy: output, consumption, hours worked and the real wage all fall together.

This analysis reveals that the timing of announcement and implementation of competitive tax reforms crucially affects the short-run dynamics implied by the reform. Because pre-announced reforms may lead to very different adjustment paths, they should also result in very different welfare effects in the short run. Overall, announced competitive tax reforms should have positive welfare effects in the short run for domestic households and unclear effects on foreign households,

Figure 3: The effects of a domestic competitive tax reform - Announced vs. unexpected



Solid black: baseline model unexpected, Dashed red: announced 4 quarters ahead, Dashed black: announced 8 quarters ahead. Variables are reported in a data-consistent manner unless specified otherwise.

as hours worked fall (positive effects on welfare) but welfare-based consumption falls (negative effects on welfare) as well.

Table 4: Welfare effects of competitive tax reforms – Unexpected vs. announced, in percents

	Unexpected			Expected (4Q)			Expected (8Q)		
Horizon	Dom.	For.	Agg.	Dom.	For.	Agg.	Dom.	For.	Agg.
1	−0.5971	0.0475	−0.2748	0.3176	0.0234	0.1705	0.1899	0.0175	0.1037
4	−0.9254	0.1139	−0.4077	0.5472	0.0543	0.3003	0.3136	0.0433	0.1781
8	−1.0628	0.1603	−0.4540	−0.3233	0.0759	−0.1241	0.4084	0.0533	0.2307
32	−0.0745	0.1049	0.0152	−0.1263	0.0847	−0.0209	−0.1412	0.0782	−0.0316
60	−0.0105	0.0503	0.0199	−0.0503	0.0437	−0.0033	−0.0601	0.0431	−0.0085
∞	0.0027	0.0177	0.0102	−0.0192	0.0166	−0.0013	−0.0246	0.0170	−0.0038

Note: A negative sign indicates a welfare loss.

Table 4 confirms that the long run effects of competitive tax reforms are slightly affected by the announcement scheme. Pre-announcement turns small lifetime welfare gains into small lifetime welfare losses (for domestic households and at the aggregate level). In the short run however, a pre-announced domestic competitive tax reform produce substantial welfare gains for the domestic economy in the first periods, up to 0.32% of consumption equivalent. They must be compared to the almost 0.6% short run welfare loss when the reform is unexpected. In the medium and long run, welfare gains and losses are less sensitive to the announcement scheme. At the 32 quarters horizon, we observe a similar qualitative pattern for gains and losses whether the reform is pre-announced or not: losses for the domestic households and gains for the foreign households. Pre-announcement is thus crucial for the way welfare gains or losses attached to competitive tax reforms materialize over time. In addition, the timing of competitive tax reforms can be manipulated by governments to produce non-negligible short-run welfare gains instead of welfare losses. Announcing competitive tax reforms might produce large welfare gains in the short-run while postponing the welfare losses (for instance after re-election).

4.5 Robustness

We finally conduct a series of robustness checks. First, we investigate the effects of permanent reforms. Contrary to nominal exchange rate devaluations, competitive tax reforms can be permanent and therefore have permanent effects. Second, we analyze the sensitivity of the welfare gains and losses from competitive tax reforms to changes in the calibrated steady-state value of hours worked, that determines the Frisch elasticity of labor supply. This should matter because the response of labor supply tailors the size of equilibrium responses of hours worked and the real wage, two variables that are crucial in our analysis. Third, we also check the sensitivity of our results to setting a much higher degree of risk-aversion $\gamma = 5$. In each of these cases, we simply report the attached welfare gains or losses, computed with our baseline model. The results can be read in Table 5.

Table 5: Welfare effects of competitive tax reforms – Robustness, in percents

	Baseline			Permanent			$\ell = 0.25$			$\gamma = 5$		
Horizon	Dom.	For.	Agg.	Dom.	For.	Agg.	Dom.	For.	Agg.	Dom.	For.	Agg.
1	−0.5971	0.0475	−0.2748	−0.4962	0.0680	−0.2141	−1.0000	0.1277	−0.4385	−0.2552	0.0303	−0.1127
4	−0.9254	0.1139	−0.4077	−0.7742	0.1484	−0.3144	−1.5139	0.2418	−0.6411	−0.3930	0.0633	−0.1656
8	−1.0628	0.1603	−0.4540	−0.8679	0.1905	−0.3408	−1.8311	0.2890	−0.7787	−0.4377	0.0858	−0.1769
32	−0.0745	0.1049	0.0152	−1.0894	0.1863	−0.4545	−0.0946	0.1332	0.0192	−0.0296	0.0734	0.0219
60	−0.0105	0.0503	0.0199	−1.1904	0.1648	−0.5161	−0.0135	0.0514	0.0189	0.0034	0.0469	0.0252
∞	0.0027	0.0177	0.0102	−1.3025	0.1599	−0.5752	0.0036	0.0141	0.0088	0.0083	0.0197	0.0140

Note: A negative sign indicates a welfare loss.

A permanent reform yields welfare losses at all horizons for the domestic households, between 0.5% on impact and 1.3% in the long run. Welfare gains are observed for the foreign households, ranging from 0.07% on impact to 0.16% in the long run. In this case, the reform reduces consumption at the intensive margin since the price of domestic goods raises permanently. It also decreases the production cost while hours worked increase. Foreign households experience positive spillovers from the reform as hours worked fall, inducing a fall in the real wage that triggers firms' entry and increases the total number of varieties, and thus aggregate productivity.

Assuming a lower level of steady-state hours worked ($\ell = 0.25$) or a larger degree of risk-aversion ($\gamma = 5$) only affects the quantitative implications of the exercise. Qualitatively, the pattern highlighted in the previous sections remains the same: welfare losses for domestic households and welfare gains for foreign households in the short run, small welfare gains both for domestic and foreign households in the long run.

5 Conclusion

To our knowledge, this paper is the first attempt to quantify the effect of competitive tax reforms in a monetary union with both endogenous entry and tradability. Countries that decide to implement these types of tax reforms experience positive outcomes on output, consumption, hours worked and the competitiveness of exports. For trade partners inside the monetary union, they generate positive output and consumption spillovers through the positive effects on the number of produced varieties (the extensive margin).

Our results suggest that the assumption of endogenous business formation crucially alters the effects of competitive tax reforms. In this environment, competitive tax reforms boost business creation both for the country that implements the reform and for trade partners in the monetary union. While these policies are *beggar-thy-neighbor* in terms of output according to alternative models, they turn out to be *prosper-thy-neighbor* in terms of output with endogenous business creation, while their ability to stabilize terms of trade is fully preserved. In addition, the aggregate lifetime welfare gains of the reform as larger with endogenous business formation.

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Appendix

A Data used for the computation of business cycle moments

We use time series for GDP, consumption, investment, employment, exports, imports, and the real exchange rate for Austria, Belgium, Finland, France, Germany, Ireland, Italy, Luxembourg, the Netherlands, Spain and Portugal. These series are taken from the OECD Economic Outlook database, and range from 1996Q1 to 2014Q2. GDP, consumption, investment, exports and imports are volume chained, seasonally adjusted, millions of PPP 2005 US dollars. Consumption is the total expenditure of households on consumption goods. Investment is the gross fixed capital formation. Employment is the total number of employed people on a National Account basis. Net exports over GDP are computed as exports minus imports divided by GDP. The real exchange rate is the trade-weighted real exchange rate index. Each macroeconomic variable is also computed at the aggregate (Euro Area) level using time-varying GDP weights when necessary (for instance for the real exchange rate). Time series are taken in logs (except net exports), they are all HP-filtered with $\lambda = 1600$ before computing the business cycle moments. Business cycle moments are computed for each country and averaged using GDP weights. The cross-country correlation is the correlation of a macroeconomic variable with the same aggregate (Euro Area) variable. Cross-country correlations are computed for each country and then averaged using GDP weights.

On a shorter sample, we also use Business Demography statistics produced by EuroStat (by legal form from 2004 onwards, NACE Rev. 2) to build measures of firms' entry at the national level. The annual time series run from 2004 to 2014 and cover Austria, Belgium, Finland, France, Germany, Ireland, Italy, Luxembourg, the Netherlands, Spain and Portugal. Because over this period France has introduced a new regulation for entrepreneurs (called "auto-entrepreneurs", that are self-employed), there is a significant upward shift in the series that could alter the business cycle pattern. We thus remove France from the sample for the business cycle moments that relate to firms' entry. Starting from these annual time series, we interpolate them on a quarterly basis, and treat them just like the above-mentioned time series. We consider the standard deviation of entry relative to GDP, the autocorrelation, the correlation of entry with output, with employment and the cross-country correlation of entry with entry at the aggregate (Euro Area) level.

B Efficient allocation and inefficiency wedges

In line with Cacciatore & Ghironi (2014), we define inefficiency wedges by contrasting the dynamics of the decentralized economy with the planner solution of the model. The latter is defined by choosing an allocation $\left\{c_t, c_t^*, \ell_t, \ell_t^*, n_t, n_t^*, y_{d,t}, y_{x,t}, y_{d,t}^*, y_{x,t}^*, z_{x,t}, z_{x,t}^*\right\}$ subject to four constraints (2 for each country). We focus on the domestic economy and consider the foreign economy as symmetric. The first constraint is the equilibrium condition on intermediate goods

$$a_t\ell_t = \frac{n_t y_{d,t}}{\nabla z_{d,t}} + (1+\tau)\frac{z_{x,t}^{-\varepsilon} n_t y_{x,t}}{\nabla z_{x,t}} + \left(\frac{n_{t+1}}{1-\delta} - n_t\right) f_e + z_{x,t}^{-\varepsilon} n_t f_x \tag{B.1}$$

and the second one is the final goods bundle combined with the equilibrium condition on retail goods

$$c_t = \left(n_t \left(y_{d,t}\right)^{\frac{\theta-1}{\theta}} + z_{x,t}^{*-\varepsilon} n_t^* \left(y_{x,t}^*\right)^{\frac{\theta-1}{\theta}}\right)^{\frac{\theta}{\theta-1}} \tag{B.2}$$

Let ξ_t denote the Lagrange multiplier attached to the second constraint and ϖ_t the Lagrange multiplier attached to the first one. First-order conditions with respect to consumption and hours worked imply

$$u_{c,t} = \xi_t \text{ and } u_{c,t}^* = \xi_t^* \tag{B.3}$$

$$-u_{\ell,t}/a_t = \varpi_t \text{ and } -u_{\ell,t}^*/a_t^* = \varpi_t^* \tag{B.4}$$

Defining $q_t = \xi_t^*/\xi_t$, the efficient allocation implies full risk-sharing among households of different countries since $q_t = u_{c,t}^*/u_{c,t}$. Hence the first inefficiency wedge will be the risk-sharing wedge, defined as $\Upsilon_{RS,t} = u_{c,t}^*/u_{c,t} - q_t$. Next, we use these expressions to define $\varpi_t/\xi_t = -u_{\ell,t}/a_t/u_{c,t} = w_t^r/a_t$. FOCs with respect to final goods demands thus imply

$$y_{d,t} = \left(\frac{\varpi_t}{\xi_t \widetilde{z}_{d,t}}\right)^{-\theta} c_t = \left(\frac{w_t^r}{a_t \widetilde{z}_{d,t}}\right)^{-\theta} c_t \tag{B.5}$$

$$y_{x,t} = \left(\frac{\varpi_t (1+\tau)}{\xi_t^* \widetilde{z}_{x,t}}\right)^{-\theta} c_t^* = \left(\frac{(1+\tau) w_t^r}{q_t a_t \widetilde{z}_{x,t}}\right)^{-\theta} c_t^* \tag{B.6}$$

$$y_{d,t}^* = \left(\frac{\varpi_t^*}{\xi_t^* \widetilde{z}_{d,t}^*}\right)^{-\theta} c_t^* = \left(\frac{w_t^{r*}}{a_t^* \widetilde{z}_{d,t}}\right)^{-\theta} c_t^* \tag{B.7}$$

$$y_{x,t}^* = \left(\frac{\varpi_t^* (1+\tau)}{\xi_t \widetilde{z}_{x,t}^*}\right)^{-\theta} c_t = \left(\frac{q_t (1+\tau) w_t^{r*}}{a_t^* \widetilde{z}_{x,t}^*}\right)^{-\theta} c_t \tag{B.8}$$

which closely track actual demand functions. Notice that total demand is made of private consumption only while decentralized demand function comprise public spending and portfolio adjustment costs. This defines an inefficiency demand wedge $\Upsilon_{D,t} = g_t + ac_{b,t}$, where efficiency requires $\Upsilon_{D,t} = 0$. In addition, comparing the above demand functions with the decentralized demand functions also allows us to define price wedges as

$$\Upsilon_{\rho_d,t} = \frac{\theta}{\theta-1}(1+\tau_{vt})(1+\tau_{\ell t})-1\geq 0 \tag{B.9}$$

$$\Upsilon_{\rho_x,t} = \frac{\theta}{\theta-1}(1+\tau^*_{vt})(1+\tau_{\ell t})-1\geq 0 \tag{B.10}$$

$$\Upsilon^*_{\rho_d,t} = \frac{\theta}{\theta-1}(1+\tau^*_{vt})(1+\tau^*_{\ell t})-1\geq 0 \tag{B.11}$$

$$\Upsilon^*_{\rho_x,t} = \frac{\theta}{\theta-1}(1+\tau_{vt})(1+\tau^*_{\ell t})-1\geq 0 \tag{B.12}$$

The price wedges are increasing in the value of mark-ups, and increasing in both VAT and payroll tax rates. The closer these wedges to zero, the more efficient the economy. Next turn to the FOCs for export thresholds, and combine with demand functions above to get

$$z_{x,t} = \frac{(1+\tau)}{(\theta-1)}\left(\frac{(\theta-1)\,w^r_t}{q_t a_t}\right)^{\frac{\theta}{\theta-1}}\left(\frac{f_x}{c^*_t}\right)^{\frac{1}{\theta-1}} \text{ and } z^*_{x,t} = \frac{(1+\tau)}{(\theta-1)}\left(\frac{q_t\,(\theta-1)\,w^{r*}_t}{a^*_t}\right)^{\frac{\theta}{\theta-1}}\left(\frac{f_x}{c_t}\right)^{\frac{1}{\theta-1}}$$

which, again, has the same overall form as decentralized export entry conditions. Comparing the efficient and decentralized export threshold conditions uncovers an additional wedge that depends on the marginal cost mc^r_t. The marginal cost should be equal to one all the time in the efficient allocation while the decentralized equilibrium makes it different from one both in the steady state (due to monopolistic competition in the retail sector with mark-up $\eta/(\eta-1)$) and after shocks (due to prices adjustment costs). Let us define this wedge as $\Upsilon_{MC,t} = 1 - mc^r_t$. The decentralized export threshold condition can be expressed as a function of key variables and wedges as:

$$z_{x,t} = \frac{(1+\tau)}{(\theta-1)}\left(\frac{(1+\Upsilon_{\rho_x})}{\left(1-\Upsilon^*_{MC,t}\right)}\frac{(\theta-1)\,w^r_t}{q_t a_t}\right)^{\frac{\theta}{\theta-1}}\left(\frac{f_x}{c^*_t+\Upsilon^*_{D,t}}\right)^{\frac{1}{\theta-1}} \tag{B.13}$$

The above equation shows that the decentralized and efficient conditions coincide when wedges are null. Finally, the conditions for the total number of varieties n_{t+1} and n^*_{t+1} implies the following efficient entry condition:

$$E_t\left[\beta(1-\delta)\frac{u_{c,t+1}}{u_{c,t}}\left(\left(f_e-\frac{n_{x,t+1}}{n_{t+1}}f_x\right)\frac{w^r_{t+1}}{a_{t+1}}+\frac{1}{\theta-1}\Psi_{t+1}\right)\right] = f_e\frac{w^r_{t+1}}{a_{t+1}} \tag{B.14}$$

where

$$\Psi_{t+1} = \left(\frac{w^r_{t+1}}{a_{t+1}\widetilde{z}_{d,t+1}}\right)^{1-\theta}c_{t+1}+q_{t+1}\frac{n_{x,t+1}}{n_{t+1}}\left(\frac{w^r_{t+1}(1+\tau)}{q_{t+1}a_{t+1}\widetilde{z}_{x,t+1}}\right)^{1-\theta}c^*_{t+1} \tag{B.15}$$

denotes the efficient gross domestic and export profits. Here too, the decentralized and efficiency entry conditions coincide when all wedges are set to zero.